Human-Centered Systems Analysis of Oceanic Air Traffic Control: Results from a Reykjavik Center Field Study

Laura M. Major, Hayley J. Davison,
& R. John Hansman

Massachusetts Institute of Technology

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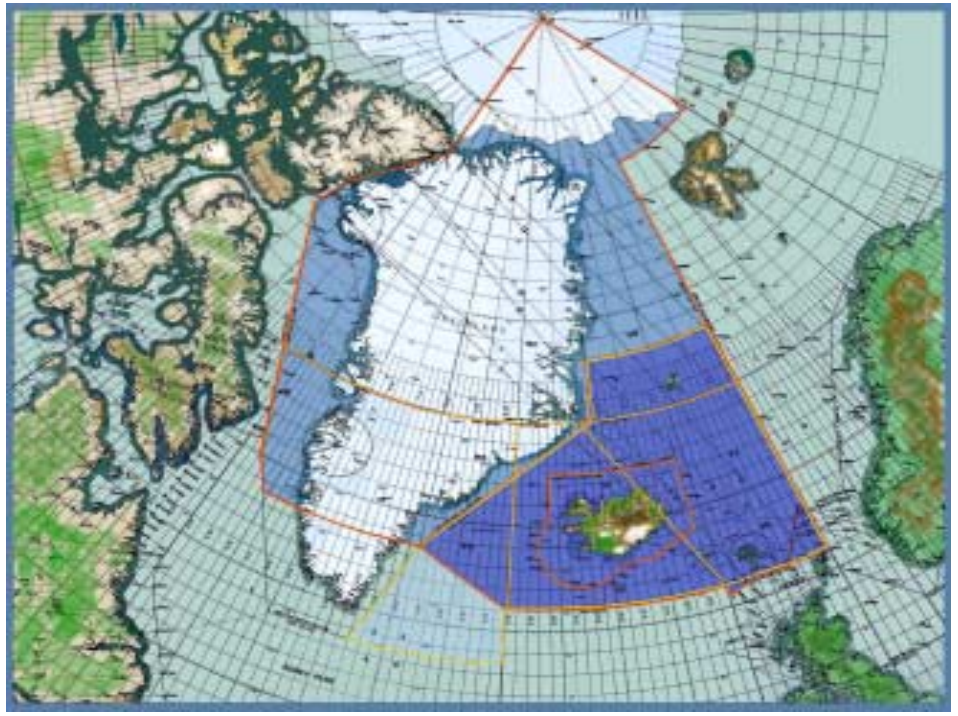
Future Oceanic Air Traffic Control System Architecture Project

- Academic:
  - **University of Iceland and MIT**
- Government:
  - **CAA of Iceland and FAA**

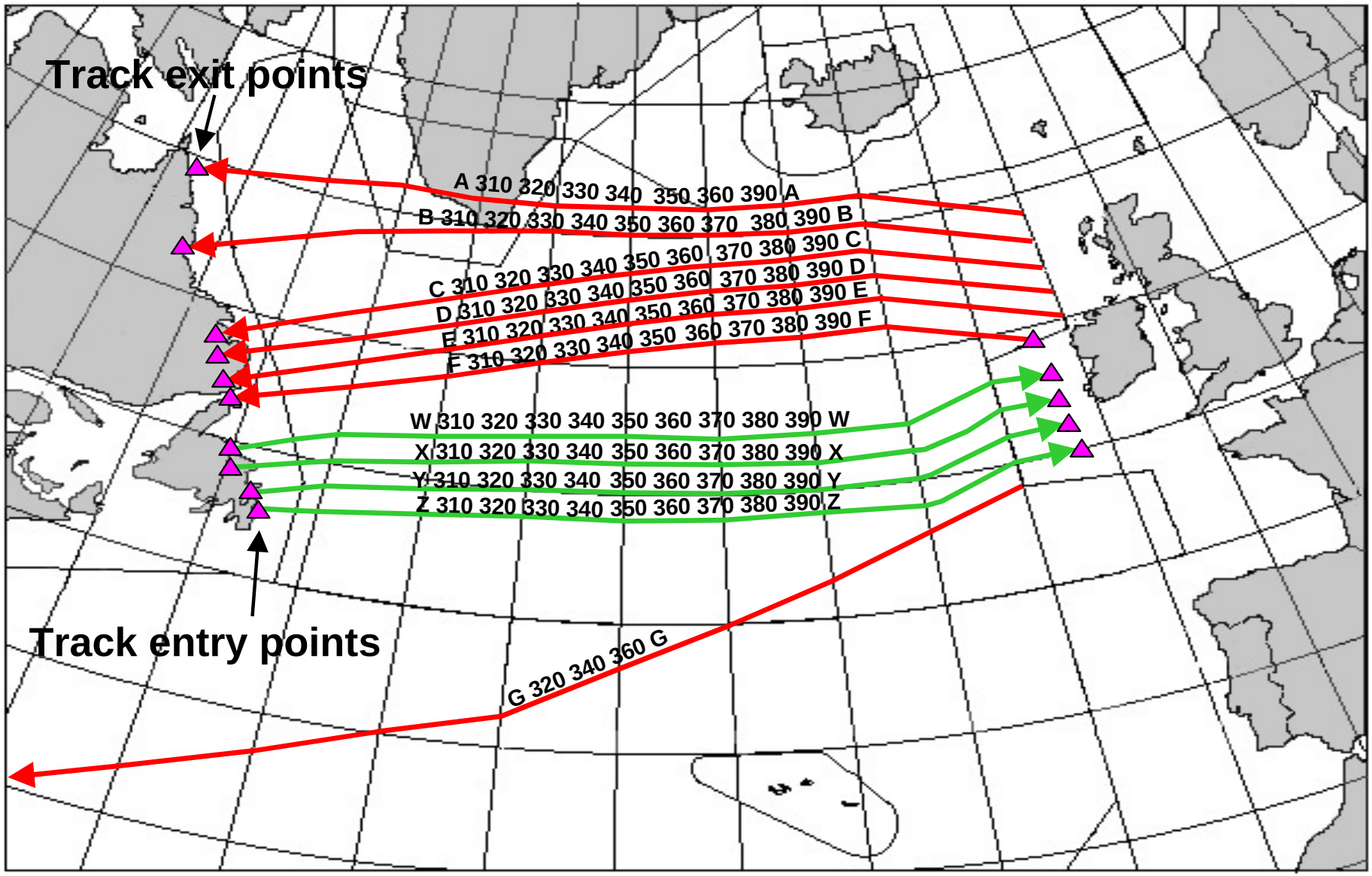
➢ Research program to evaluate Human Factors in Future Oceanic Air Transportation Systems Architecture



Motivation

- Increased traffic and emphasis on safety in the oceanic environment demand:
  - Reduced separation minima
  - More efficient routing
- Oceanic air traffic control systems and processes are evolving and new technologies (e.g., ADS), integrated information systems, and new procedures (e.g., RVSM) will likely be incorporated.
- This new environment will influence the tasks of the controller and pilot, therefore human factors considerations should be integrated into the design from the beginning

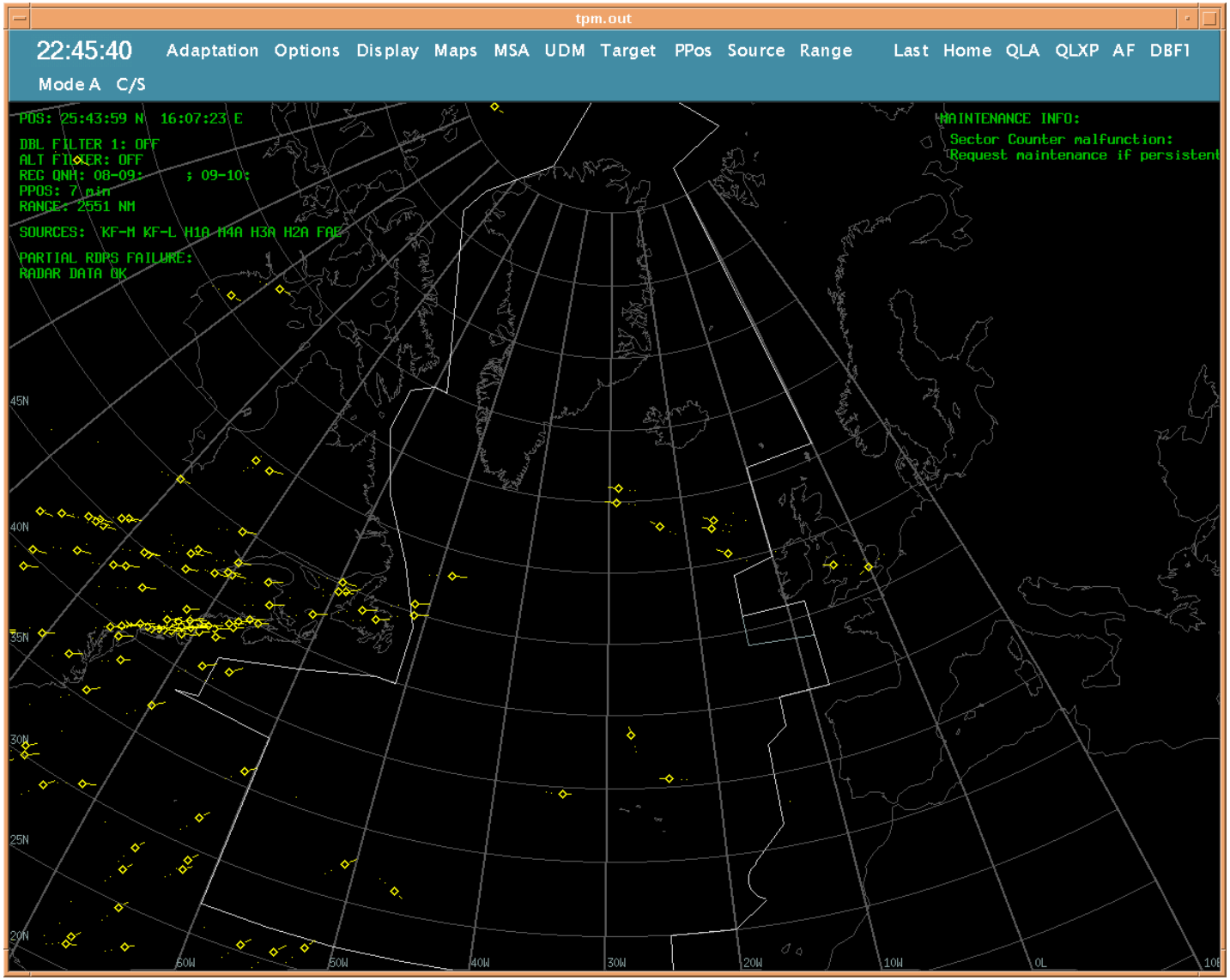
North Atlantic Tracks



courtesy of Tom Reynolds

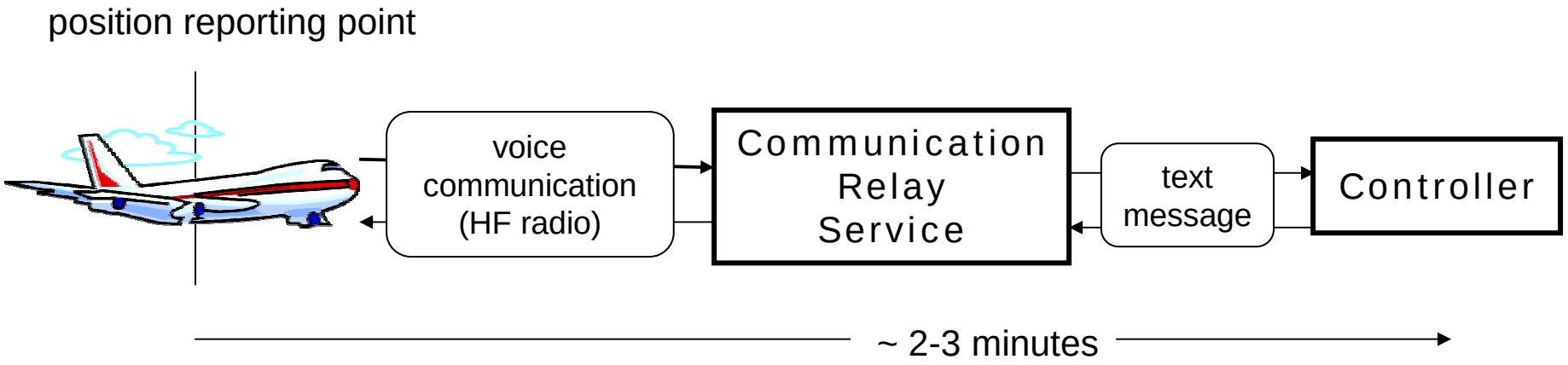
North Atlantic Traffic

24 – hour period



developed for NICE study

Oceanic Surveillance Limitations



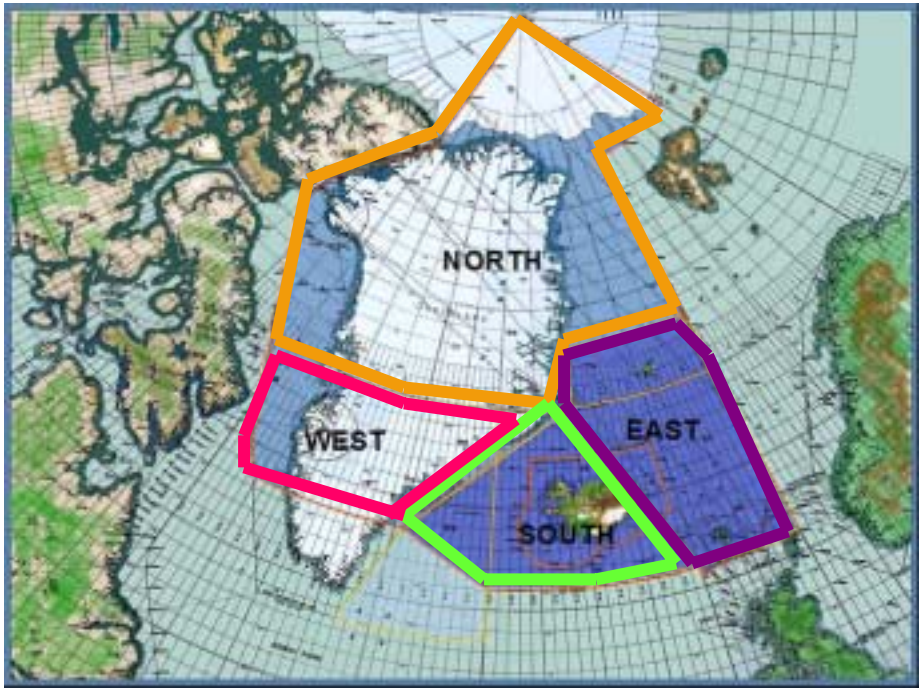
- Delayed surveillance and command path demand large separation requirements
- Missed position reports, which frequently occur become a time sink
- New technologies (e.g., satellite communication and ADS) are slowly being integrated into oceanic operations

Site Visit Methodology

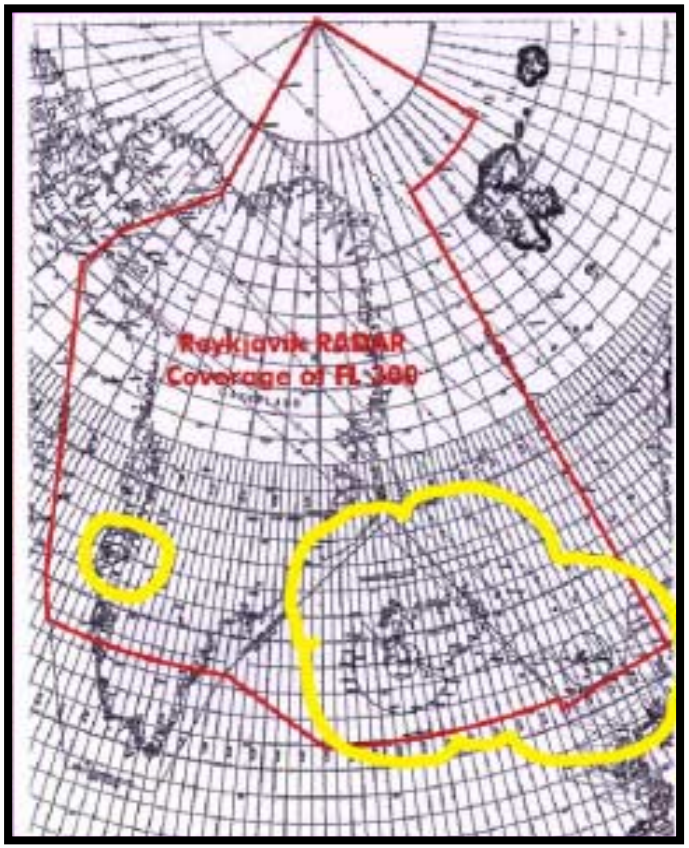
- Reviewed New York & Reykjavik Center Operating Procedures & Job Task Analyses to **formulate preliminary cognitive model**
- Conducted initial site visits to **refine cognitive model**
  - New York Air Traffic Control Center
    - gathered initial understanding of the oceanic environment
    - one 4-hour exploratory observation
  - Reykjavik Air Traffic Control Center
    - four 4-hour focused observations
    - observed:
      - 13 Controllers (5 Oceanic, 8 both Oceanic and radar)
      - 1 Chief Controller
      - 1 Supervisor
      - 1 Training Instructor

Reykjavik Center Observation Results

Overview of Reykjavik Center



- Airspace divided into 4 sectors: **North**, **South**, **East**, **West**



- 80-90 % of South and East sectors are covered by radar (shown in yellow)

Current Reykjavik Workstation

- workstation in North/West sector
- South/East sectors also have single radar display

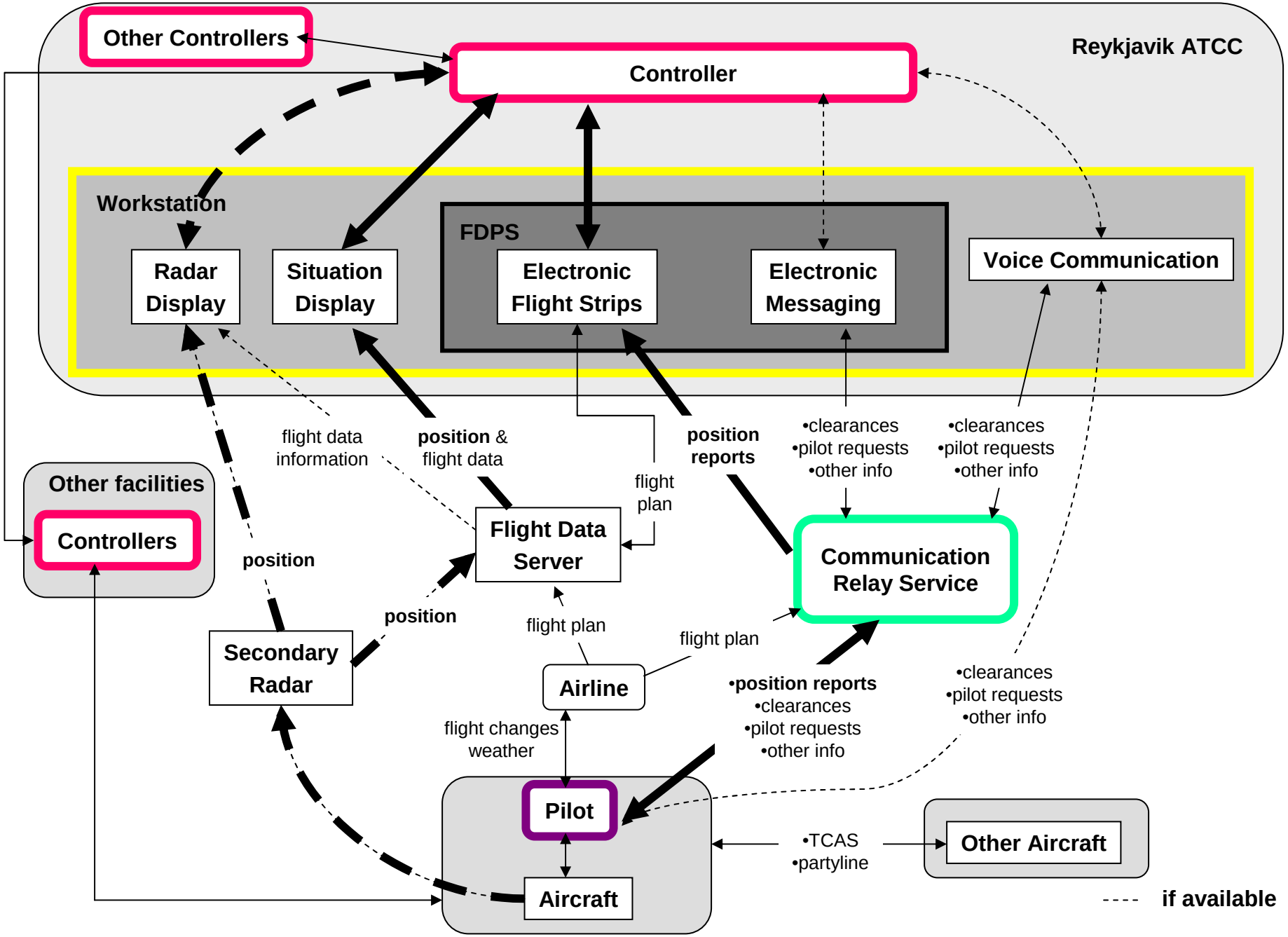
Map of Iceland airspace

Notes from Supervisor

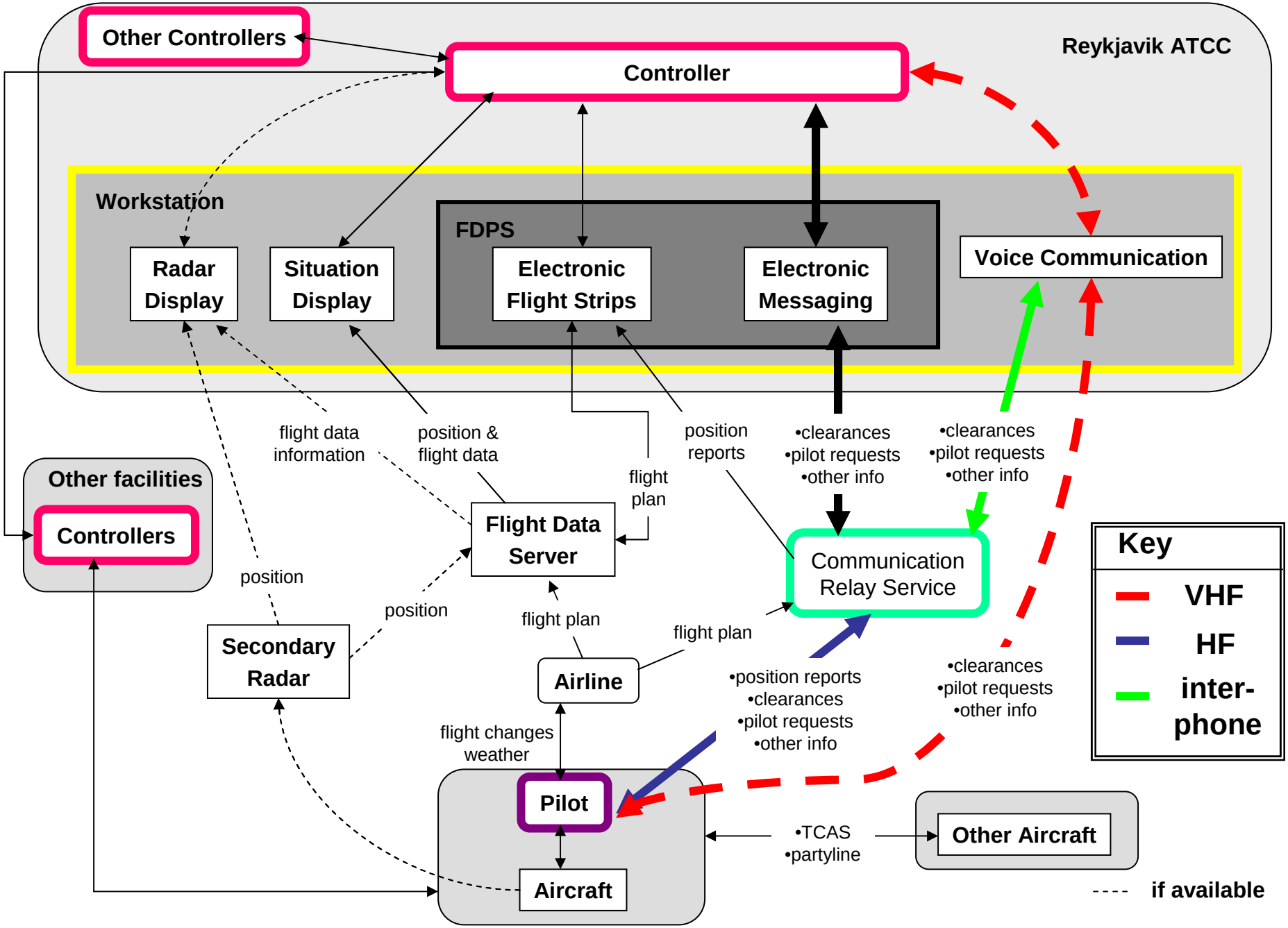
Situation Display

Flight Data Processing System

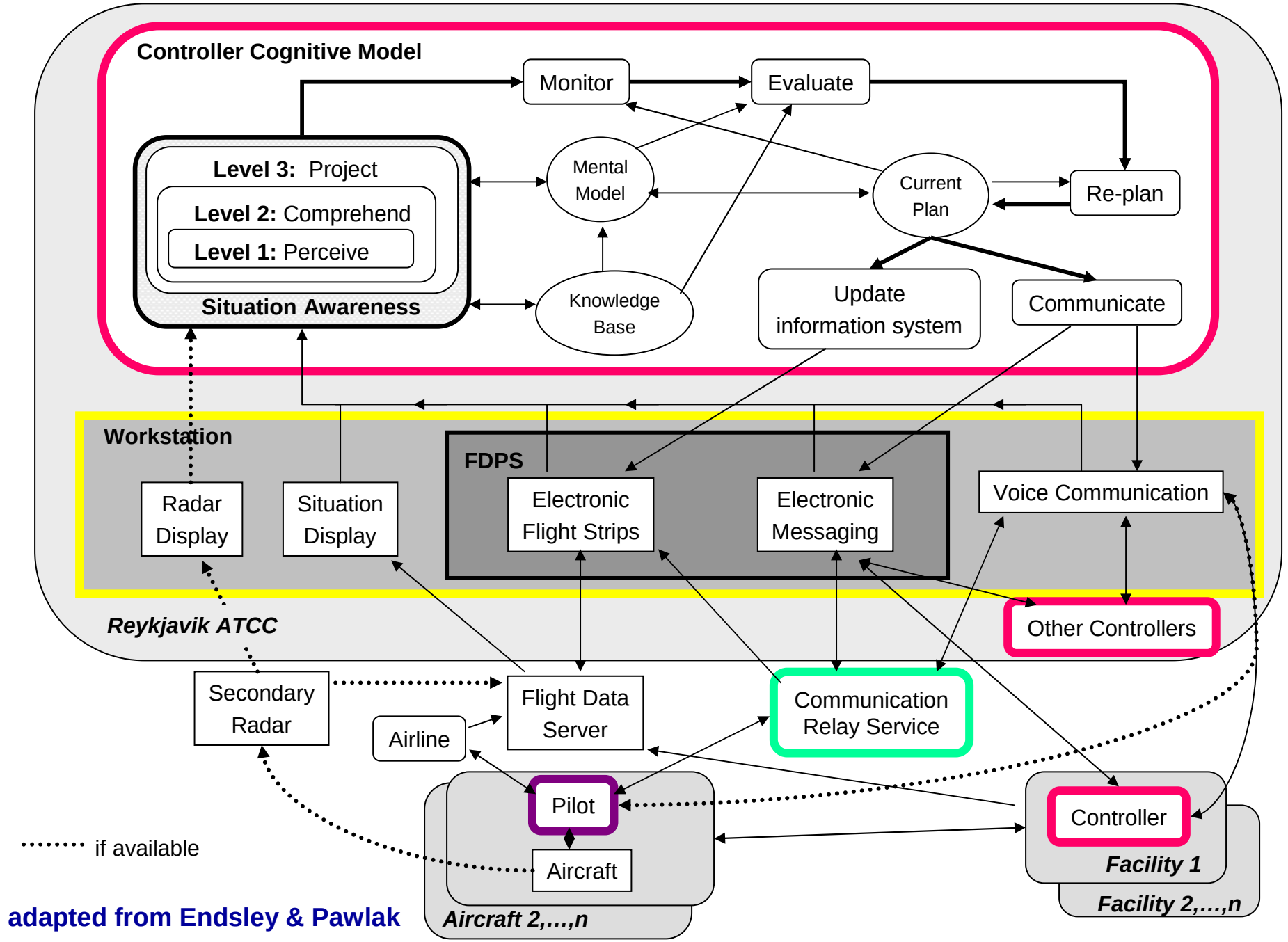
Information Flow – Surveillance paths



Information Flow – Communication paths

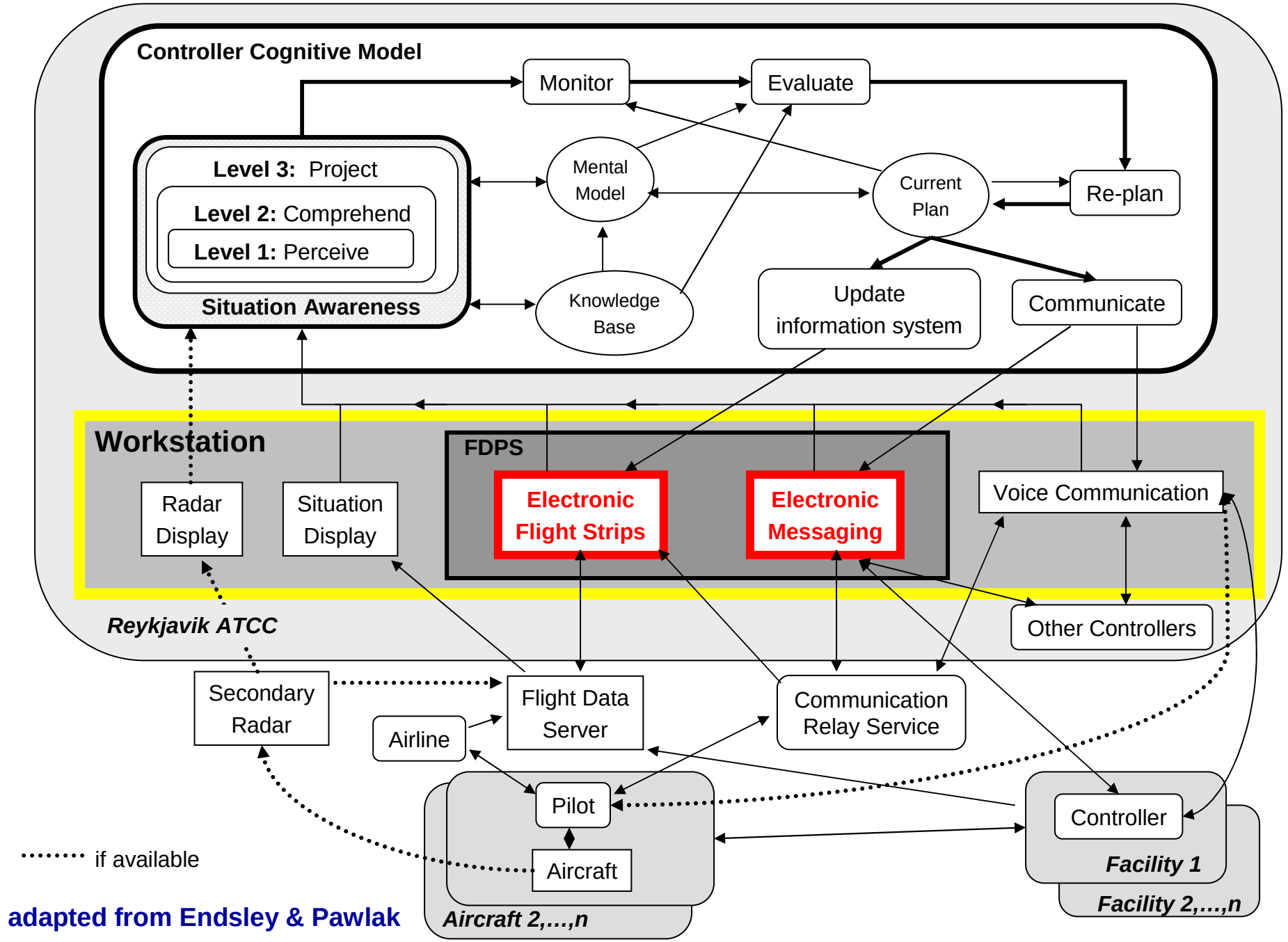


Integrated Cognitive System Model



adapted from Endsley & Pawlak

Integrated Cognitive System Model



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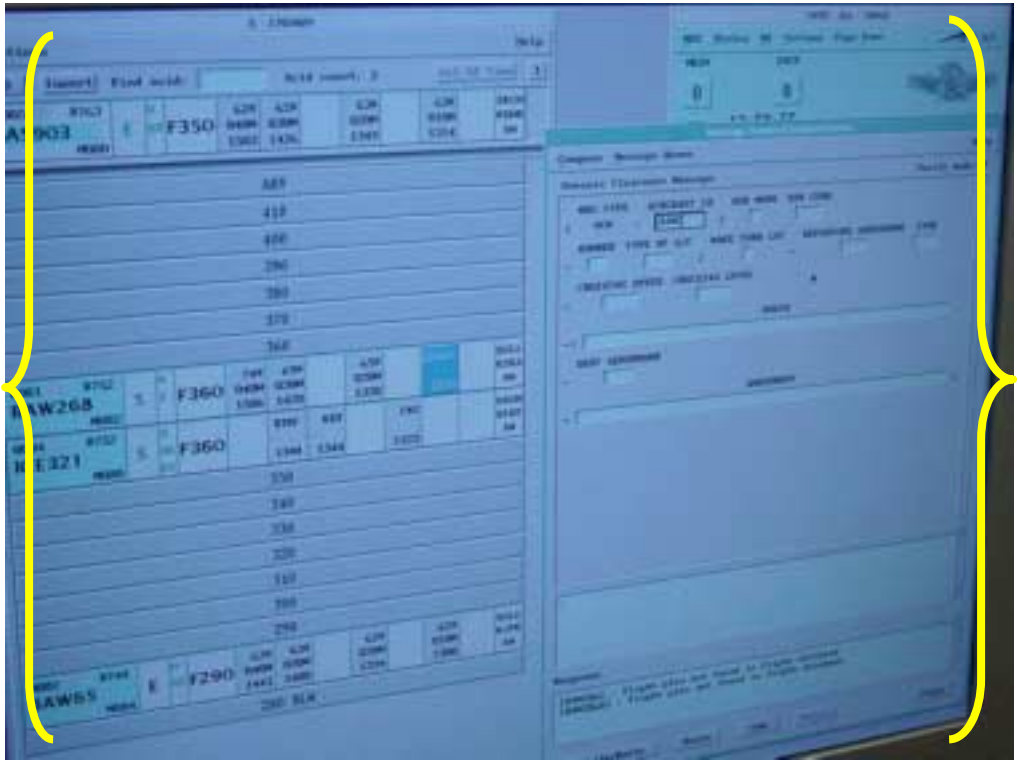
Flight Data Processing System

flight strips

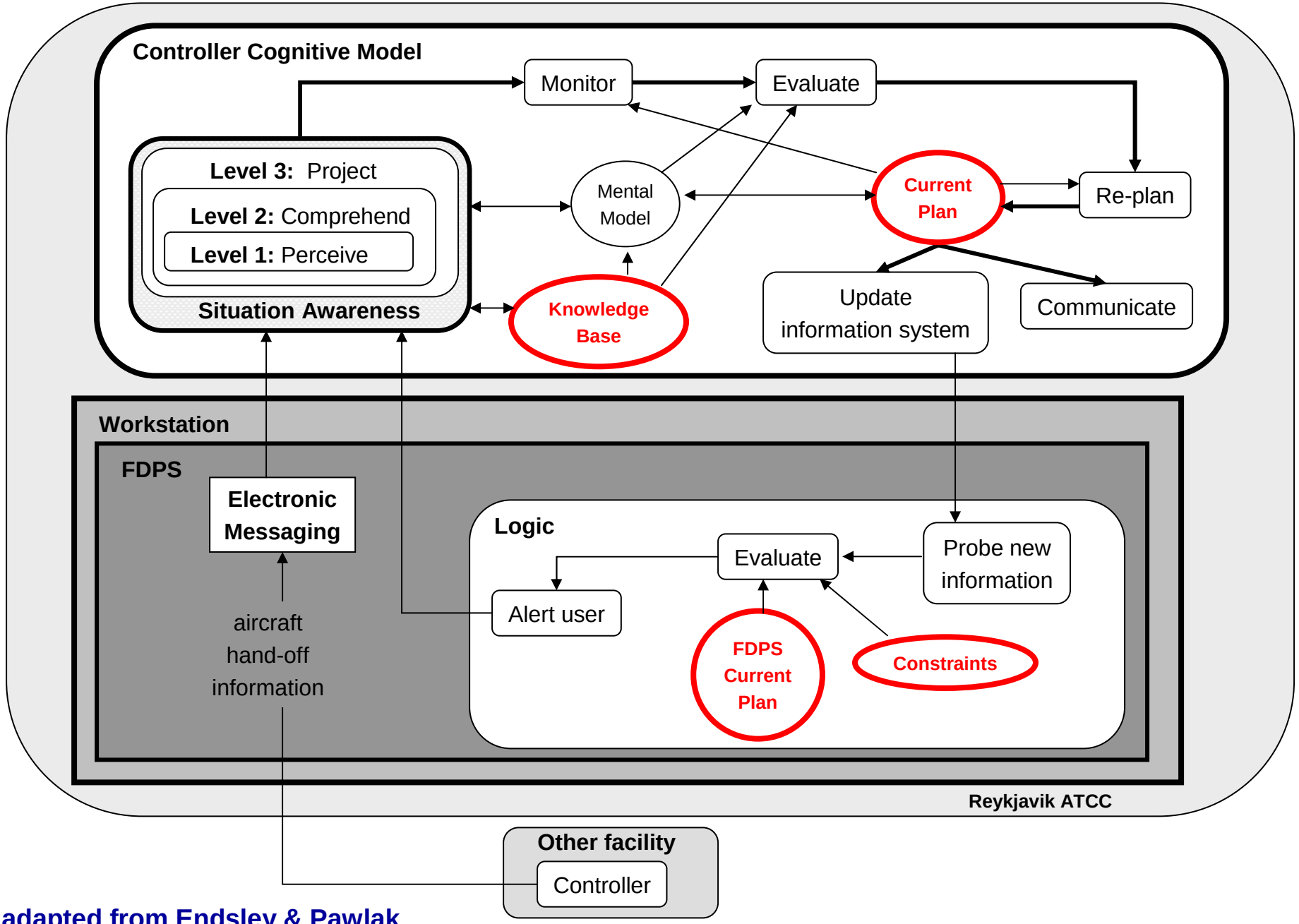


electronic message

Limitations cited by controllers:

- **window view**: cannot get a snapshot overview of strips, have to scroll
- **trust:**
  - new system
  - electronic information – have to print out paper strips in case of a breakdown
- **nuisance warnings:** conflict warnings, coordination warnings, etc

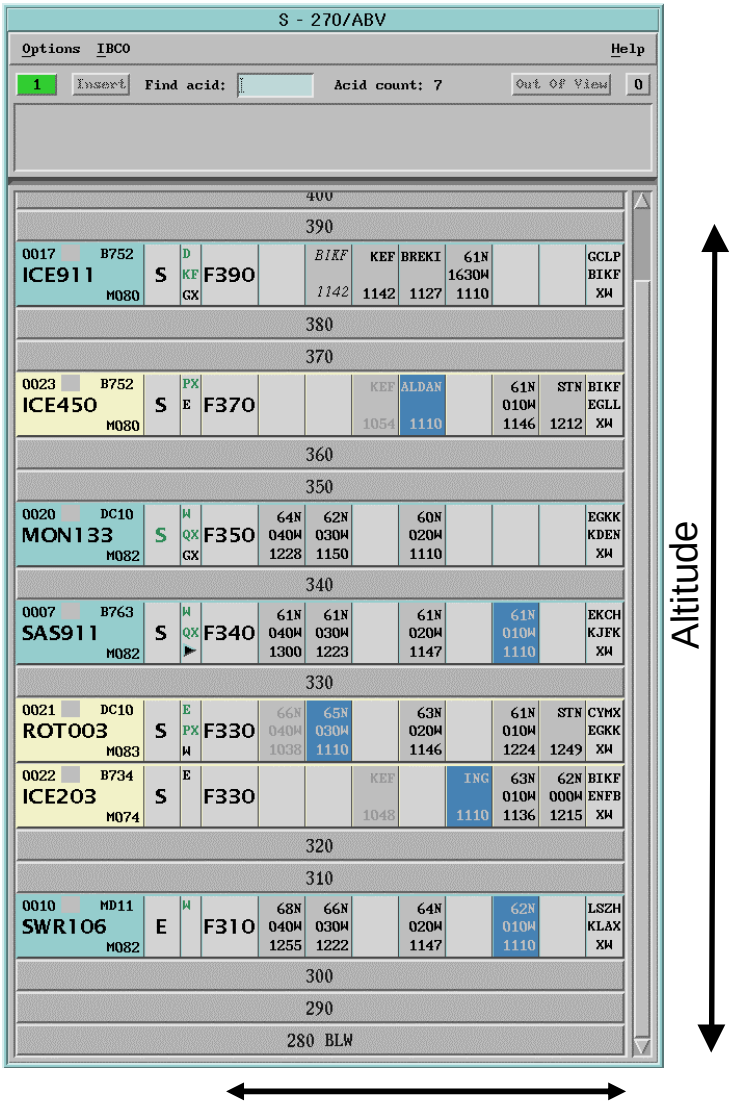
Analysis of Conflict Detection Alerts – Ex: Aircraft hand-off



adapted from Endsley & Pawlak

Electronic Flight Strips

- Flight strip direction, time, and altitude groupings provide **structure-based abstractions** for controllers:
  - Strip arrangement (position matrix) mimics traffic structure
  - Color represents direction of flight (westbound are turquoise & eastbound are yellow)



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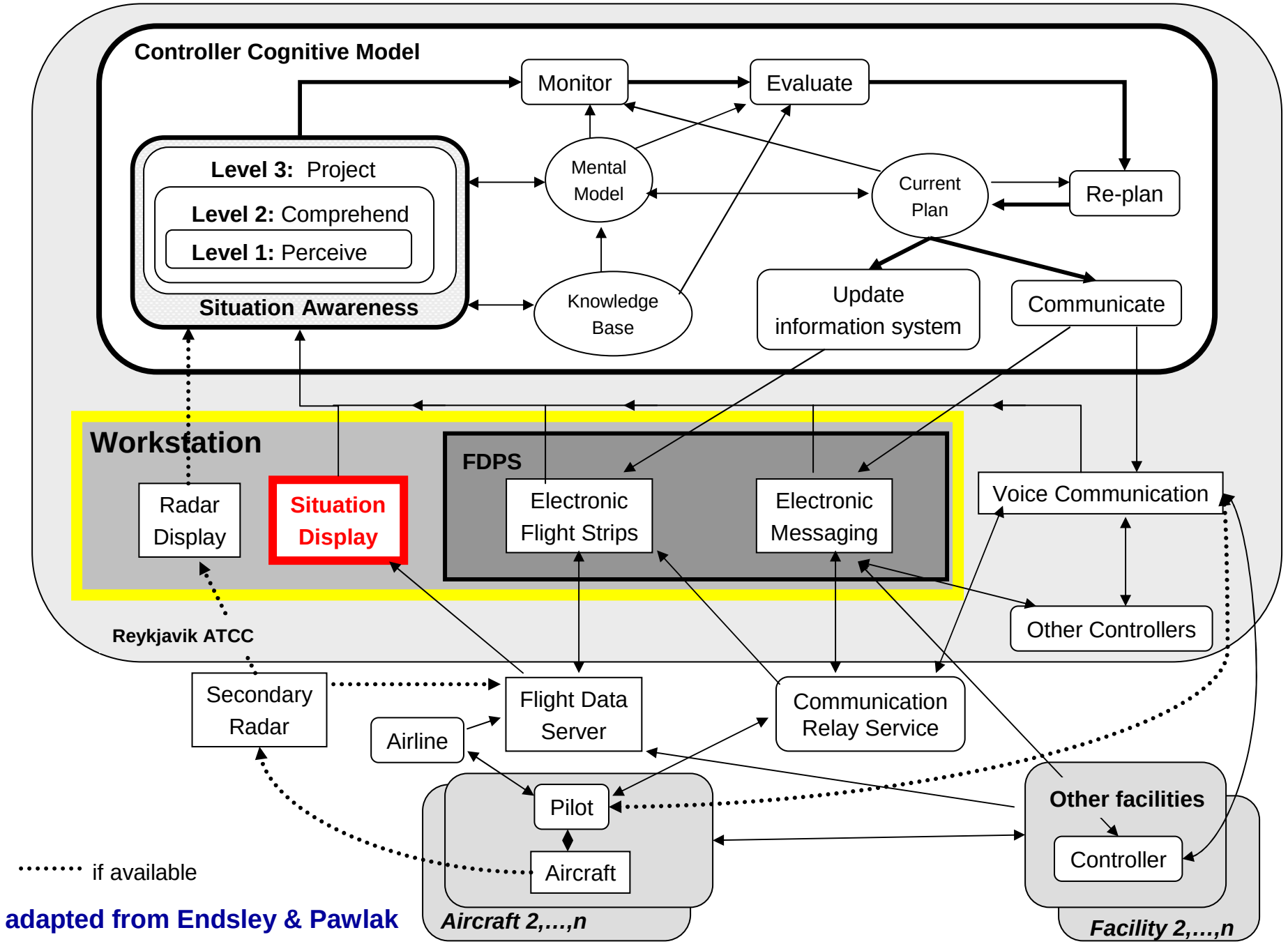
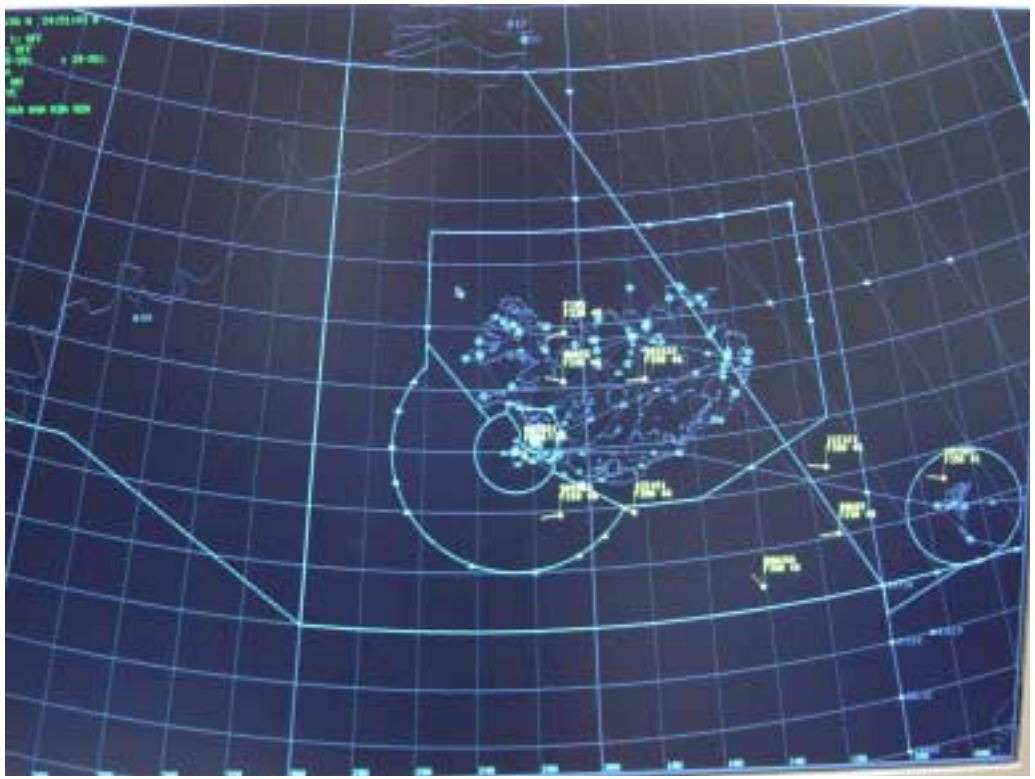


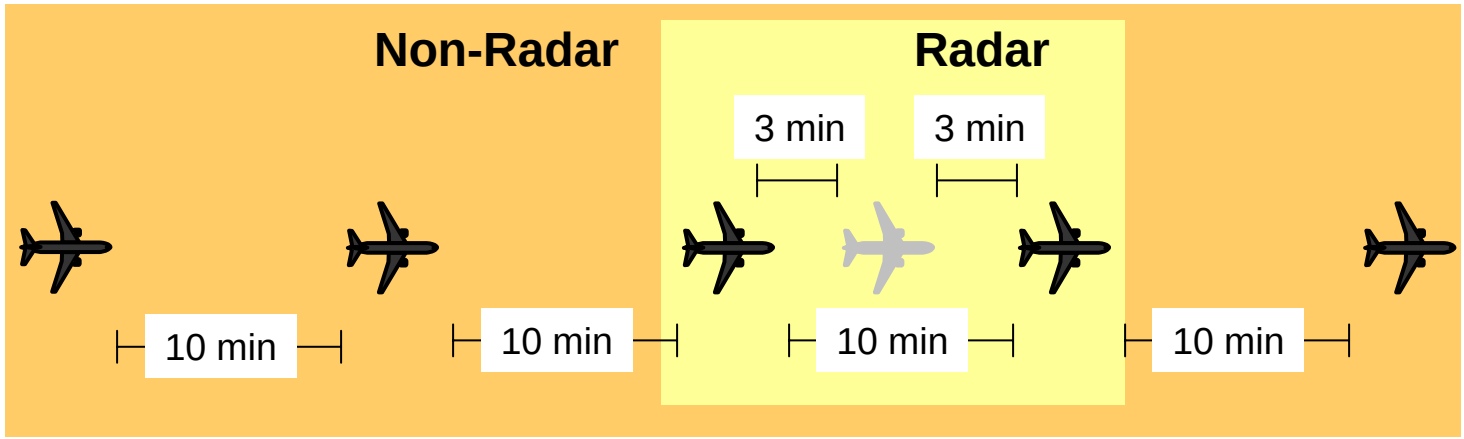
adapted from Endsley & Pawlak

Situation Display

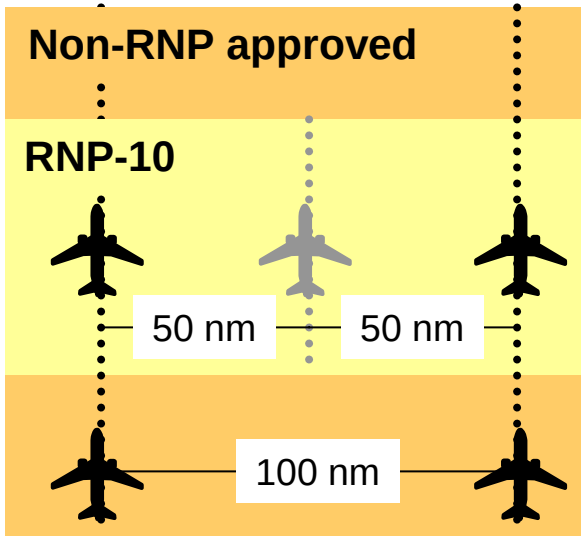
- Graphically depicts extrapolation of aircraft path based on flight strip assumptions
- Not utilized as much as expected
- **Time constraints** in the procedural sectors encourage a methodical strip comparison, however it is more conducive to use the Situation Display with **spatial constraints**
- Currently, Iceland's Operating Procedures encourage use of Situation Display to assist in separation, but **require that controllers tactically ensure separation using strips**
- Controllers in mixed environment have to cognitively integrate **nearly continuous information** from radar screen with **discrete information** from Situation Display



Issue of Transitioning Boundaries



Ex: *Non-Radar:* 10 minutes *Radar:* 3 minutes



Ex: *Non-RNP approved:* 100 nm *RNP-10:* 50 nm

- Different boundaries **negate the advantage of technologies** and procedures such as radar, RNP, RVSM, and ADS
- Controllers in mixed equipage environment may not apply reduced separation standards in order to **reduce operational complexity**, **maintain situation awareness** and **manage workload**

Process Analysis

Phase I: **Pre-Arrival in Sector**	Phase II: **Arrival in Sector**	Phase III: **Traversal through Sector**
~30-45 minutes before aircraft reaches airspace boundary	Aircraft enters airspace	Aircraft in sector airspace: arrival – hand-off

based on observations and interviews

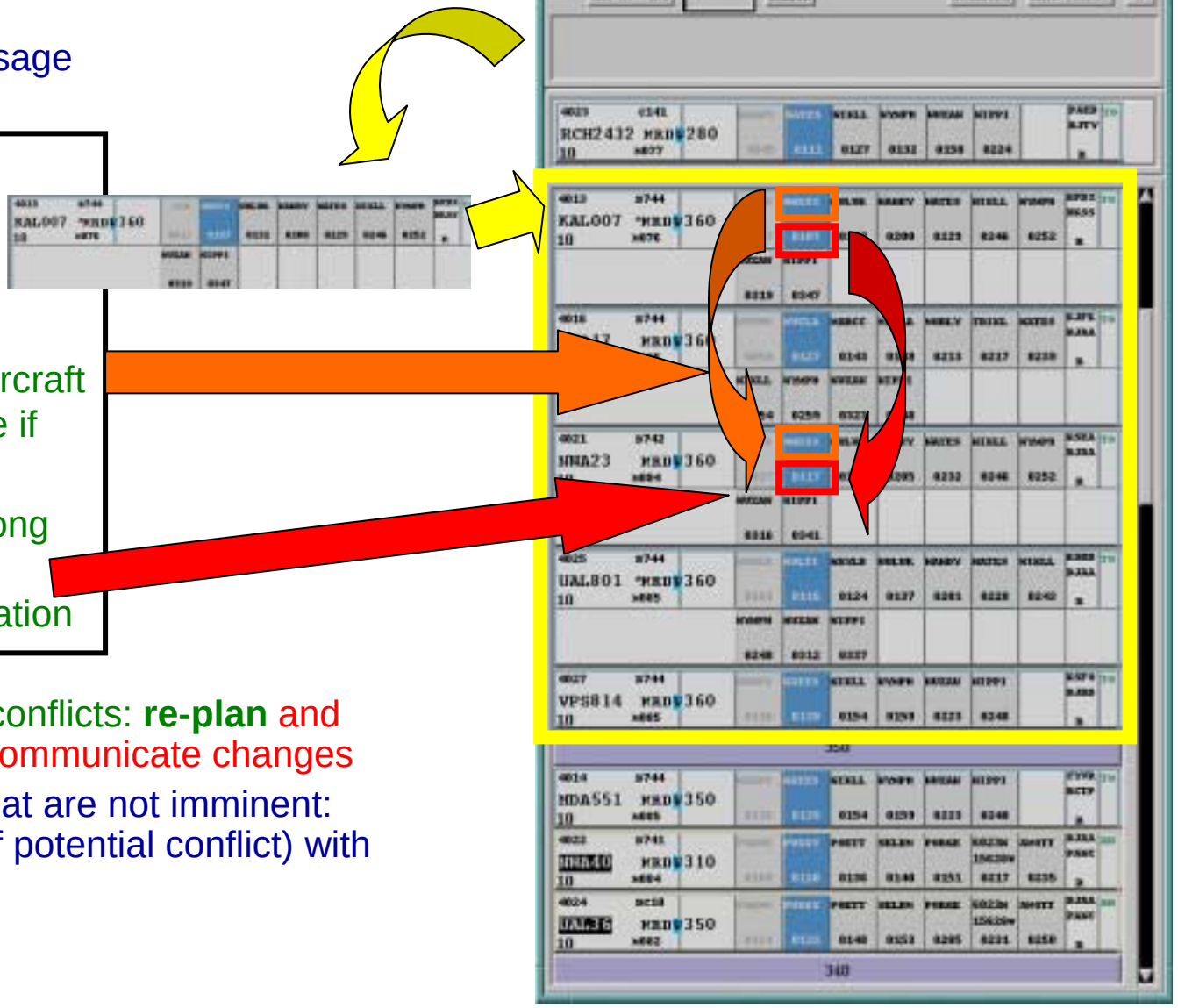
Phase I: **Pre-Arrival in Sector**

data manipulation
cognitive processes
communication

- Adjacent facility calls to transfer control
- Flight strip arrives in message center on FDPS

Procedural Projection to Identify Conflicts

- Put Flight Strip in flight level grouping
- Compare waypoints for aircraft on same flight level to see if any match
  - ➢If waypoints match along route: compare time to ensure adequate separation



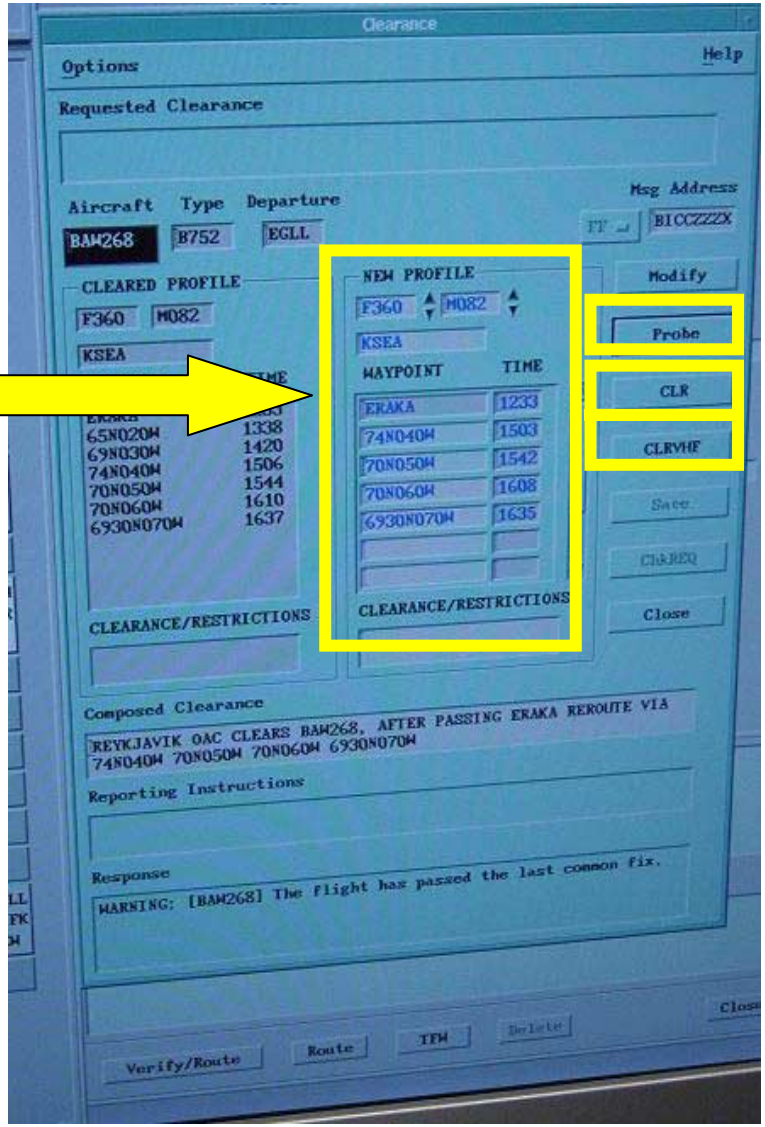
➢If there are imminent conflicts: **re-plan** and ask adjacent facility to communicate changes

➢If there are conflicts that are not imminent: "tag" strip (under time of potential conflict) with an underlined red flag

Phase II: **Arrival in Sector**

data manipulation
cognitive processes
communication

- CLEARANCE window comes up on FDPS (sent by adjacent facility)
- Check flight strip for underlined “tag”
  - ➢If “tagged”: **evaluate** situation
    - ➢If there are conflicts: **re-plan** & modify clearance, by editing NEW PROFILE
- Press PROBE
  - ➢If conflict warning appears: **evaluate** to determine if it is a false alarm
    - ➢If there is a true conflict: **re-plan** & modify clearance by editing NEW PROFILE
    - ➢ press PROBE again
- **Communicate command** by either:
  - Pressing CLR
  - Pressing CLRVHF and call pilot



Phase III: **Traversal through Sector**

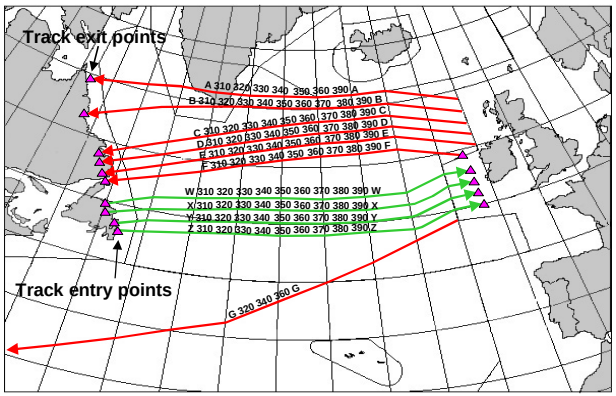
- **Monitor** for additional information, deviations from “current plan”, and overdue aircraft
- **Re-plan** only when necessary:
  - predicted loss of separation
  - turbulence
  - restrictions from adjacent facilities
  - emergencies
  - special occurrences
  - …

Structural Abstractions

- Studies show that structure provides the basis for air traffic controller abstractions, which significantly influence cognitive processes and reduce controller workload (Davison, Histon)
- Identified structural abstractions:

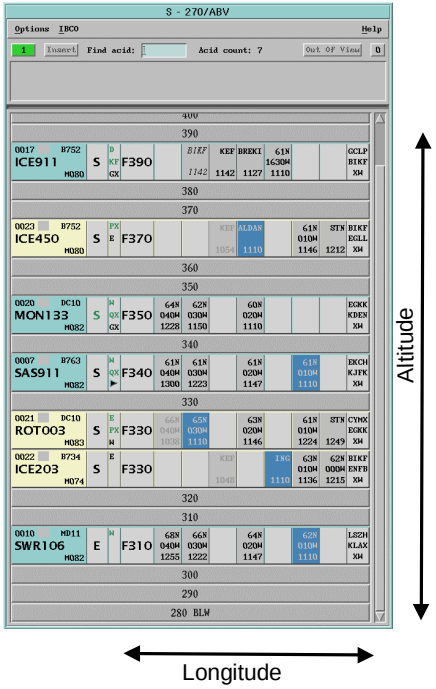
Standard Flows:

North Atlantic Tracks



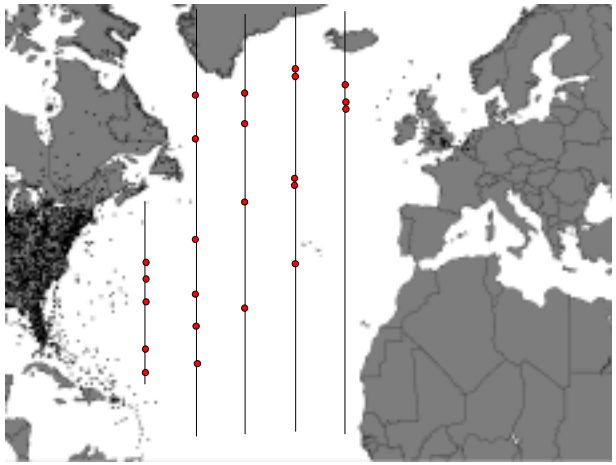
Groupings:

Flight Strip Arrangement



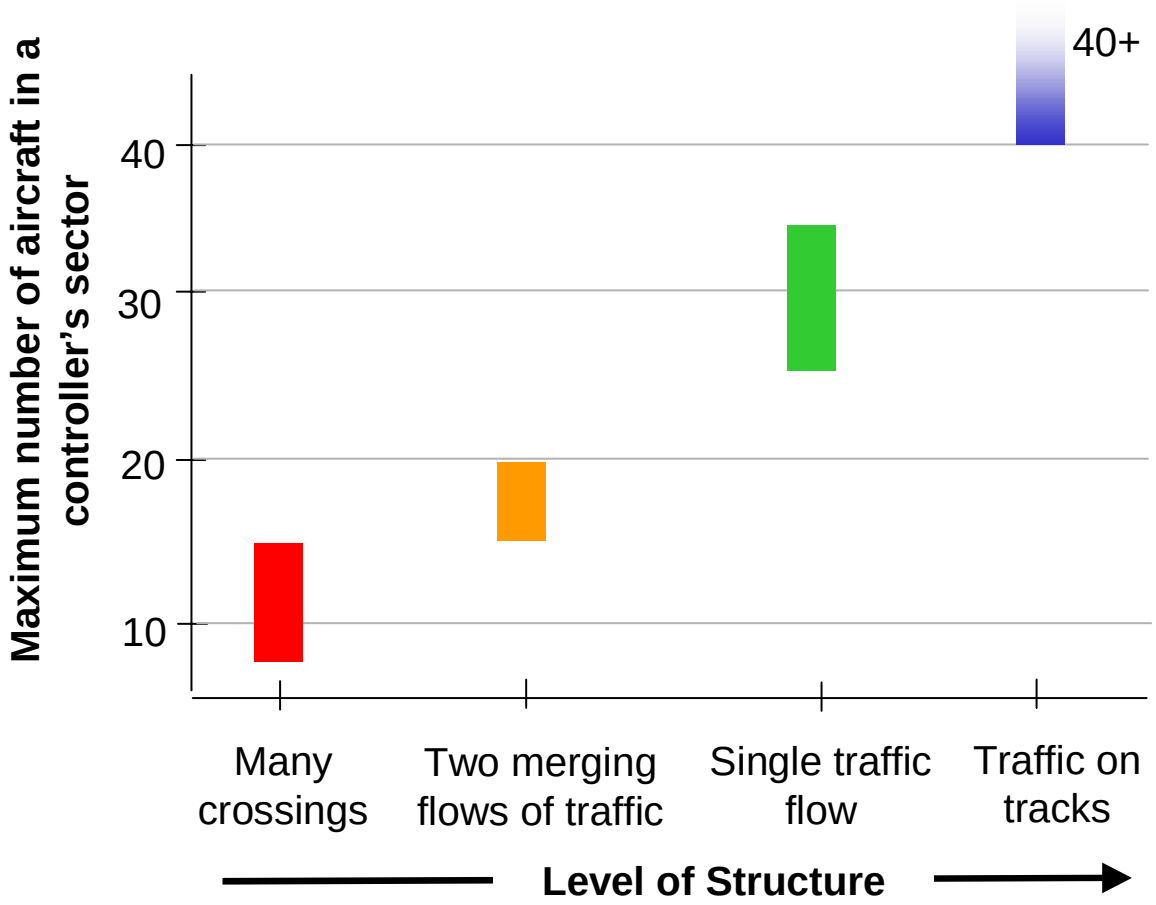
Critical Points:

Position Report Points



Workload as a Function of Structure

- Several Reykjavik controllers reported that they are cognitively able to handle more traffic as structure increases



Key Preliminary Observations I

1. **Delayed surveillance** and **command path**, and **missed position reports** disrupt the controller-centered control loop:
   - The integration of new surveillance (e.g. ADS) and communication (e.g. satellite communication) technologies is necessary to mitigate the problems caused by procedural surveillance

2. **Nuisance warnings**, **lack of controller trust** in alerts, and the **limited window view** of the electronic flight strips distract the controllers cognitive processes rather than support them:
   - Automation limitations need to be overcome in order to support the controllers cognitive processes

Key Preliminary Observations II

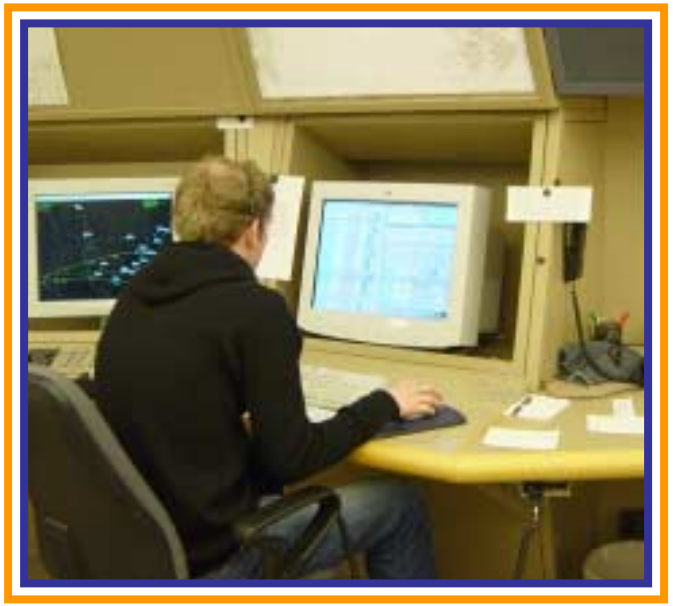
3. Providing ADS information and fully integrating the Situation Display could innately change the **projection task** of the controller from a **time-based** projection to a **spatial-based** projection, therefore:
   - Consideration should be given to the type (spatial or time) of separation requirements given to the controller in the future

4. The mixed equipage issue of **transitioning boundaries of different performance** needs to be carefully considered in order to avoid negating the advantage of new technologies and procedures

Future Plans

- Continue to **develop cognitive model**
- Conduct **focused observations at U.S. facilities** for comparative analysis in order to identify similarities and differences between U.S. and Iceland
- Based on current cognitive model **project the future of oceanic ATC** and the effect of introducing new technologies such as ADS
- Further **investigation into key issues** identified in conjunction with Tern Systems in Iceland

Questions



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